

Diseases of *Banksia* woodlands on the Bassendean and Spearwood Dune Systems

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Current knowledge

Diseases of *Banksia* woodlands have been a neglected area of plant pathology. Of the c 250 000 publications on plant diseases abstracted in the Review of Plant Pathology since 1922, only about 30 refer to diseases of *Banksia*. Only 6% of these 30 publications refer to diseases of *Banksia* in woodlands compared with 55% for forest and 39% for *Banksia* species used in floriculture. Observations on the impact and spread of *Phytophthora cinnamomi* by Podger (1972) and Havel (1979) are the only published account of disease on *Banksia* woodlands of the Bassendean Dune system. Nevertheless, despite the lack of published information, disease is an important factor affecting the ecology of *Banksia* communities.

Phytophthora species have been the most frequent cause of disease of *Banksia* (73% of the 30 publications) followed by wood rots (12%), leaf spots (9%) and *Cylindrocladium scoparium* (6%). The leaf spot *Asterina systema-solare* (Shivas in press), wood rots caused by *Armillaria luteobubalina* (Shearer & Tippet 1988), *Ganoderma*, *Polyporus*, *Poria* and *Stereum* (Hilton collection, WA Herbarium) and the canker pathogen *Botryosphaeria ribis* (Shivas in press) have been recorded on *Banksia* species occurring on the Bassendean Dunes. However the most destructive impact on the *Banksia* community of the Bassendean Dune system is disease caused by *Phytophthora* species, especially *P. cinnamomi* (Podger 1968, 1972).

Phytophthora cinnamomi is distributed widely in *Banksia* woodlands of the coastal plain killing most of the overstorey and shrub layers in affected areas (Podger 1972). Incidence of disease is greatest south of Perth, decreasing north of Wanneroo (Havel 1979). The Moore River National Park is the most northerly known occurrence of *P. cinnamomi* on the coastal plain. Geographically restricted and susceptible *B. loricata* is being killed in affected areas in this park. The incidence of *P. cinnamomi* on the Spearwood Dunes is much less than on the Bassendean Dunes (Podger 1968), even though plant species are susceptible and disturbance from human activity is high (Havel 1979).

Phytophthora cinnamomi is an introduced soil-borne fungus belonging to the Oomycetes or "water moulds". As the name "water mould" suggests, the life cycle of *P. cinnamomi* depends on moist conditions that favour survival, sporulation and dispersal of the fungus, and host infection. Warm, moist conditions and interactions with soil microflora favour vegetative production of sporangia and thick walled chlamydospores from mycelial strands in the soil or host tissue. Interaction of mycelium of different mating types may produce thick-walled sexual oospores. However reproduction in soil is mainly by the asexual

sporangium-zoospore cycle which produces large numbers of infectious spores when conditions are favourable.

Sporangia release motile zoospores in free water. Zoospores can swim over short distances in water, but are mainly dispersed over large distances in flowing water or in infected moist soil moved by human activity. Zoospores in moist soil are chemotactically attracted to root surfaces where they germinate to produce germ tubes that penetrate roots. Infection by *P. cinnamomi* is probably favoured by the thin bark and proliferation of rootlets associated with the specialized proteoid roots of the *Banksia* species occurring on the Bassendean Dunes. The fungus actively grows through root systems or is passively dispersed in infected roots transported in soil. Root to root contact facilitates mycelial growth between root systems and initiation of new infections.

The pathogen infects at least 1000 species of known hosts from taxonomically diverse families (Zentmyer 1980). The families Epacridaceae, Myrtaceae and Proteaceae, important components of *Banksia* woodlands, contain many susceptible species.

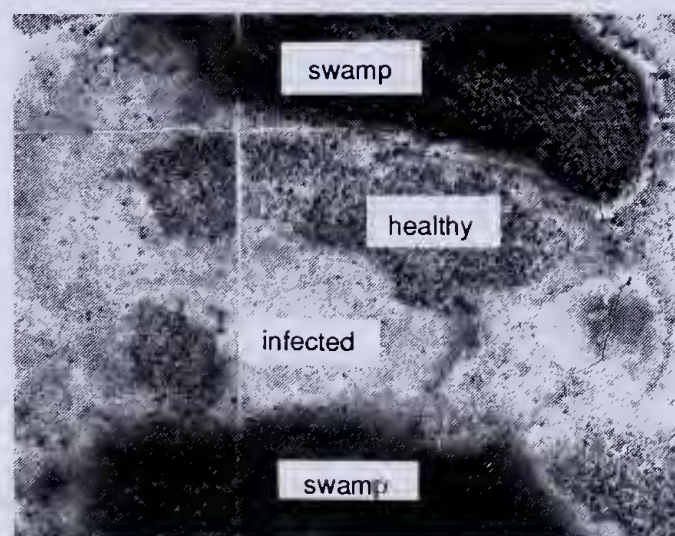


Figure 1 Destruction of *Banksia* woodland following infection by *Phytophthora cinnamomi* (light grey) compared with remnants of healthy woodland (dark grey) on a gently sloping Bassendean Dune between two swamp systems at Gngara on October 1964. The infected area was healthy woodland prior to 1953. Scale 1:12 500.

Current research

Following Podger's (1968) initial monitoring of sites from Ravenswood to Moore River, little research has been done on the occurrence of *P. cinnamomi* in *Banksia* woodlands on the coastal plain. Investigations are now in progress to determine the factors influencing disease development, impact and methods of control of *P. cinnamomi* and other *Phytophthora* species in *Banksia* woodlands.

Disease Development

The spread of *P. cinnamomi* in 132 ha of Bassendean Dunes at Gnarang has been mapped from aerial photographs. The area includes 97 ha of *Banksia* woodland and 35 ha of ephemeral swamp. Four small patches of dead vegetation totalling 0.15 ha occurred in 1942 alongside tracks that radiated from nearby strawberry farms. The area of infected woodland and swamp had increased to 55 ha by 1959, because of expansion of original infections, new infections from a nearby farm and contamination of the swamp system with associated destruction of low lying *Banksia* woodland (Fig. 1). These disease fronts expanded at 1.0 m yr^{-1} and 67 ha was infected by 1974, increasing to 82 ha (63%) in 1988. Slope or depth to water table did not appear to influence the rate of spread. However the rate of spread at Gnarang was slower than a mean downslope spread of 8 m yr^{-1} observed by Podger (1968) on a gently sloping dune of Gavin sand in the Bassendean system near North Dandalup.

The pattern of disease development at Gnarang reflects the ability of *P. cinnamomi* to exploit various mechanisms of spread. Disturbance associated with market gardening, roads, tracks and off-road driving have resulted in the dispersal of *P. cinnamomi* in infected soil, and is responsible for the widespread distribution of the pathogen throughout the coastal plain. Active and passive dispersal of zoospores in free water contributes to spread within an area and results in the contamination of swampy areas. Zoospore dispersal in coarse-textured sands may also be assisted by movement of the water table or by lateral drainage from perched layers of saturated soil over clay or iron hardpan. We have recovered the fungus from groundwater at 3 and 5 m below the soil surface in affected *Banksia* woodland on Gavin sand near Hamel and south of Busselton. Growth of *P. cinnamomi* in roots of susceptible hosts ensures continued spread through summer, even though activity of the fungus in dry soil ceases. For example, *P. cinnamomi* can grow up to 1 cm day^{-1} in roots of susceptible *B. grandis* in summer when temperatures are optimal for fungal growth (Shearer *et al* 1987).

The destructiveness and persistence of *P. cinnamomi* in *Banksia* woodlands is partly determined by the ability of the pathogen to survive the dry soil environment over summer and resume activity when moist conditions return. The fungus survived throughout the year in soil sampled from a depth of a metre in an affected *Banksia* woodland on Gavin sand south of Busselton. Recovery rates at depth from this site were often higher than those obtained from a high impact site in the jarrah forest.

Infected host tissue provides a buffered environment for *P. cinnamomi* survival during dry conditions. For example, the fungus survived summer in 65% of colonized pine plugs buried at 30 cm in an affected area at Gnarang, even though soil moisture at this depth decreased to 0.6% in February.

Impact

Phytophthora cinnamomi infection destroys the structure and diversity of *Banksia* woodland. The dominant overstorey of *B. attenuata*, *B. ilicifolia* and *B. menziesii* is killed and only scattered *Eucalyptus tottiana* and *Nuytsia floribunda* remain in affected areas. Many understorey shrub species are similarly affected. Species richness in 64 m^2 quadrats decreased from 56 species

in healthy woodland to 41 species in an affected area. Biomass can be reduced by up to 90% following infection (Fig. 1). Despite the impact of *P. cinnamomi* on *Banksia* woodland, information is lacking on the long term structural and floristic changes in affected areas.

Other *Phytophthora* species

Phytophthora citricola, *P. cryptogea* (A₁), *P. megasperma* var. *megasperma* and *P. megasperma* var. *sojae* have been isolated from dying vegetation on Bassendean Dunes north of the Moore River. Many of the affected areas were low-lying and seasonally inundated or received off-road drainage. The susceptibility of native vegetation to these *Phytophthora* species needs to be determined before their relative significance to the health of native plant communities can be accurately evaluated (Shearer *et al* 1988).

Control

Eradication of *P. cinnamomi* from spot infections by Ridomil and fumigation with formaldehyde is being assessed in Jandakot sands of the Bassendean Dunes at Gnarang with promising results. In addition, the systemic fungicide phosphorous acid has arrested lesion extension in *B. grandis*. Evaluation of these control methods is continuing.

Conclusions

Systematic surveys of *Banksia* woodlands in southwestern Australia are needed to address the lack of information on diseases of *Banksia*.

Phytophthora cinnamomi and other *Phytophthora* species are major factors affecting the ecology and management of the diverse, but susceptible, *Banksia* communities on leached sands. Information is lacking on the specific requirements for pathogen survival, sporulation and spread as well as host infection and susceptibility in sandy soils. Such information is essential for the development of hazard and risk systems to minimize introduction and spread of *Phytophthora* species.

Knowledge of the diversity of *Banksia* woodlands, similar to the site-vegetation classification of Havel (1979), is needed in the development and application of hazard and risk systems. Long term effects of *Phytophthora* spp on diversity clearly needs to be quantified.

An understanding of the low incidence of *P. cinnamomi* on Spearwood Dunes may provide clues for the control of the disease. Control strategies must be developed and applied to prevent spread and intensification of disease favoured by disturbance caused by increasing urbanization and sand mining.

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